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AGAINST THE MICROFOUNDATION HEGEMONY: COOPERATION IN BIOLOGY, BUSINESS AND ECONOMICS

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Abstract: *We use recent insights from evolutionary biology and the principle of biological relativity to reveal the remarkable parallels between forms of cooperation in biology, business and economics. The principle of biological relativity states that there is no privileged level of causation. The creation of higher levels of organisation and regulation constrains the components of co-operation in a form of downward causation. The upward and downward forms of causation are not equivalent. Downward causation is an organising principle arising from the ordered creation of the 'initial' and 'boundary' conditions experienced by the lower level components. But the existence of the lower level components is also the necessary condition for the creation of the higher-level constraints.*

Very similar processes are at work in corporations. The restrictions imposed by the legal form of the corporation bind investors to the provision of permanent capital in a similar way to that of fusion of organisms in biological processes, creating a form of symbiogenesis. The higher order conditions imposed on the agents of the firm provide an organising principle and the existence of the lower level agents is a necessary condition for the creation of the higher-level constraints.

Furthermore, the process of entry into new business environments resembles that of symbiosis or symbiogenesis in that the interaction is asymmetric; the subsequent process is dynamic, resulting in super-additivity. The dynamic processes can create higher levels of organisation, such as new business models involving cooperation between businesses, corporations, regulators and governments. These in turn constrain the entities forming the new process.

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1. Introduction

The aim of this article is to apply new developments in evolutionary biology to the fields of economics and management. There have been many extensions and developments of theories of evolutionary biology since the first formulation of the Modern Synthesis (neo-Darwinism) 70-80 years ago (Huxley 1942; Mayr 1982). We will refer to that synthesis as Classical Neo-Darwinism, which was essentially based on three key assumptions:

1. Random variations in inherited characteristics (essentially Mendelian genetics).
2. Natural selection acting on the resulting variants (Darwin's great idea).
3. Impossibility of inheritance of acquired characteristics (the Weismann Barrier theory).

These assumptions led to the most commonly used models in theories of economics and other social sciences. In particular the simple framework of evolutionary biology represented by «selfish gene» theory became a cornerstone of theories in economics using the same equilibrium models.

However, recent trends in evolutionary biology have seriously challenged the main assumptions: that individuals act either selfishly or cooperatively just as their genes are supposed to do; that they optimise their selfish interests; and that their interactions with other individuals can be represented as a process in equilibrium rather than a dynamic one far from equilibrium.

All of these assumptions have been challenged by developments since the Modern Synthesis. Furthermore these developments have significant consequences for models in economics and management.

Examples of these developments and new trends can be found in the Extended Evolutionary Synthesis (Pigliucci and Müller 2010), the «New Trends in Evolutionary Biology» issue of the Royal Society journal *Interface Focus* (Bateson *et al.* 2017), on the website of THETHIRDWAYOFEVOLUTION, and in the books by Shapiro (Shapiro 2011), Noble (Noble 2006; Noble 2016) and the book edited by Huneman and Walsh, *Challenging the Modern Synthesis. Adaptation, Development and Inheritance* (Huneman and Walsh 2017).

1.1. *Previous Work in This Field*

Some of the consequences of these developments for theories of economics have already been shown by acknowledged pioneers of this emerging interdisciplinary field, such as Vermeij (Vermeij 2006; Vermeij and Leigh 2011), Akcay (Akcay *et al.* 2013; Akcay 2017; Akcay, Linksvayer, and Van Cleve 2015), Nowak (Nowak 2006) and Roughgarden (Roughgarden 2009; Akçay and Roughgarden 2011). We are not therefore the first to draw attention to the need to incorporate observations and ideas on co-operative, in addition to selfish, behaviour in biology into theories of economics and other social sciences. But we believe we are the first to do so in the context of the Principle of Biological Relativity, formulated by one of us in the Royal Society

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journal *Interface Focus* in 2012 (Noble 2012), and to draw out the striking parallels between cooperation in the three fields.

The Principle of Biological Relativity was first formulated as a mathematical necessity: the differential equations of reductionist approaches to modelling the dynamics of biological processes cannot be solved without specifying the structural, initial and boundary conditions, which can be seen to represent respectively the physical, historical and environmental contexts in which the processes occur. Downward causation from those higher-level contexts is therefore a necessity. Higher levels constrain lower levels. This is the core principle that we will apply in this article.

Such constraints are also based on established experimental facts:

(a) What is usually regarded as the lowest level of biological activity, *i.e.* genes defined as DNA sequences, is not itself an active cause. DNA on its own does nothing. Unlike proteins, which can be active as catalysts, transporters and mobile filaments, DNA is inert until activated by higher-level biological networks. As Watson first remarked when the double helix was discovered, it is a passive template.[1] This fact is also why viruses, which are largely composed of DNA or RNA, need to enter a cell to replicate.

(b) The process of faithful replication is not itself a property of DNA, which is actually a poor replicator. It is a property of higher level protein and lipid networks that correct the natural copy error rate from around 1 in 10^4 base pairs to less than 1 error in replicating a whole genome, *i.e.* around 1 in 10^{10} base pairs (Noble 2018).[2]

(c) DNA sequences coding for RNAs and proteins are activated and controlled by many transcription factors and epigenetic factors that represent the integrated control activity of biological networks in cells (Noble 2016 Chapter 3).

(d) The cell, including all the control mechanisms, is the fundamental unit of inheritance. Classical neo-Darwinism incorporated this fact since it was based on the idea that the germ line cells are the sole transmission of inheritance and that they are isolated from the rest of the organism, which is the Weismann Barrier hypothesis.

(e) The Weismann Barrier is now known to be permeable, which means that many of the higher-level control processes can be inherited through the germ line (Lavitrano *et al.* 1989; Spadafora 2018; Smith and Spadafora 2005; Noble 2019; Posner *et al.* 2019). Another way of expressing this fact is that the Weismann Barrier cannot be «embodied in the Central Dogma of molecular biology» (Noble 2018).

(f) There has been extensive lateral transmission of inherited factors (RNAs and DNAs) in the course of evolution, including the processes of symbiosis, symbiogenesis and natural genetic engineering (Margulis 1981; Shapiro 2011).

[1] www.dnalc.org/view/15474-RNA-s-role-in-the-cell-James-Watson.html.
[2] https://en.wikipedia.org/wiki/DNA_replication.

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We will apply all of these principles and experimental observations as our article develops.

2. Biological Background

In this section of our paper we will outline the main biological discoveries that require a co-operative (symbiotic) view of evolution to complement the widely-held gene-centric view.

There are many examples of symbiosis, symbiogenesis, and related processes in biology. They have been the basis of the major critical transitions in evolution (Maynard Smith and Szathmáry 1995; Margulis and Sagan 2003). The evolution of eukaryotes (cells with internal organelles like nuclei, ribosomes, etc) from prokaryotes (cells lacking such organisation) was such a transition, making possible the development of multicellular organisms. Symbiogenesis of this kind is irreversible. There is no way in which the mitochondria in the cells of our bodies, for example, could 'wander off' to become free ranging bacteria again. Most of their DNA has already been fully integrated into the nuclear DNA of the host cells, which their ancestors must have invaded, or, to reverse the description, which our ancestors swallowed whole. This integration illustrates the outcome of the dynamic changes that follow co-operative transitions in biological evolution, and which can lead to irreversible transitions. The dynamics of these transitions will be shown to be similar to the dynamic (non-equilibrium) changes that occur between business, regulatory and governmental agencies before and following penetration of a corporation into new markets. Government & Regulatory actions can be seen as equivalent to boundary conditions, while the path dependency can be seen as equivalent to initial conditions.

The forms of co-operation that fall short of symbiogenesis involve symbiosis, which is reversible and can take many forms. The transition to an irreversible co-operation is of great importance to our paper since we will describe the forms of interactions that lead to comparable irreversibility in economics and management.

Symbiotic and symbiogenetic interactions are essentially asymmetric; the word «absorption» is helpful as one tries to visualise the nature of what is happening in this particular kind of fusion. Such interactions through absorption are intrinsically non-linear and it is these non-linear processes that can lead to irreversibility. To understand the survivability of a fused object created by symbiosis it may still be helpful to also model the behaviour of its de-fused components to see if they are 'tempted' to break away.

For absorption to lead to survivability it must be beneficial: as in the neo-Darwinist synthesis, the fused object must possess greater success in competing for resources than the separate components. That is to say, the new life-form which is created must survive and reproduce better than do the separate components, so that its characteristics progressively become dominant in the population. Clearly, for survivability, a penetration must be mutually beneficial. When this happens we can speak of «cooperation through fusion by means of absorption».

This idea – of cooperation through absorption – is obviously important for a general understanding of evolution. For example, all eukaryote organisms (whose cells

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contain nuclei and other organelles) developed from the fusion-through-absorption (symbiogenesis) of different species of unicellular organisms. And the evolution of multicellular organisms could also be regarded as a form of *self*-symbiogenesis between originally symmetric cells, as in the multicellular phase of organisms like the Amoeba *Dictyostelium discoideum* (Gilbert 2006).

3. An Example: the Foraminifera-Algae Symbiosis

Foraminifera are so-called because they are unicellular organisms that form calcium carbonate shells with numerous holes (foramen) that not only shelter the foram itself but also allow algae to colonise the shells. A single foram can host many algae, depending on how large it grows itself and how large its shell is. The significant feature of this interaction is that it is not just a passive sharing of protection. Both organisms are active in providing metabolic help to each other. The forams benefit from the algae's photosynthetic ability to produce energy-giving sugars, while the algae benefit from the CO_2 and other metabolites produced by the forams, just as plants do generally (Brasier 2009, 2012).

The result is not just a novel form of life. It is a collaboration that, in fact, has enabled the forams to slowly evolve and to thereby become much larger and more abundant. The resulting increase in size is astonishing. From a microscopic cell invisible to the naked eye (*i.e.* much less than 0.1 mm diameter) the forams can develop to become as large as 120 mm in diameter, and to form shells that can be likened to elaborate castles with many chambers. They have been so successful that the great pyramids and sphinxes of ancient Egypt were constructed of stone laid down by the foraminifera over hundreds of millions of years.

This kind of co-operative symbiosis is enormously successful precisely because of the asymmetric and non-linear nature of the interaction; what we have called absorption. Such asymmetric interactions are not represented in selfish gene models and in the kin-selection models, and in the group-selection models that have grown out of this way of thinking. Asymmetric interactions create new levels of organisation that are a part of what evolutionary change actually is. Cooperation can involve such creation and is well illustrated by the way in which single cell amoeba-like organisms called foraminifera co-operate with algae to form the corals.

The benefits to both species are so great that the forms created can continue to co-operate for millions of years during which their size and dominance of their niche can grow spectacularly (Brasier 2009, 2012). In some cases, the process does go all the way to full symbiogenesis. The transition to an irreversible co-operation is of great importance to our paper since we will describe the forms of interactions that lead to comparable irreversibility in economics and management.

4. The Implications of Fusion by Absorption

To summarize:

(i) Existing models of social interactions in biology suffer from the defect that, apart from allowing the organisms/agents to possess or adopt different characteristic kinds of behaviour (non-altruistic, altruistic), the agents are otherwise

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symmetric, essentially the same species. But many of the most interesting interactions during evolutionary history have been between asymmetric agents that have enabled novel properties and new forms of life to emerge. Hybridisation is a stimulus to speciation (Shapiro 2014; Noble and Noble 2017).

(ii) Many of the existing models are usually static, concerned with analysing equilibria. They do not normally account for the dynamic changes that occur, such as dramatic increases or decreases in the size of objects – exemplified by the increase in the size of the foraminifera (Brasier 2009, 2012). This is a systems process that can only be understood dynamically in terms of the progressively increasing benefits that the symbionts enjoy as a result of their interaction. Algebraic equilibrium models do not represent these dynamics. An exception is the introduction to differential equation models in evolution (Barton, Briggs, and Eisen 2007 chapter 28), but such approaches are still not widely used.

(iii) The best strategy for an organism seeking to cooperate with an established environment may well be to seek to penetrate it – to create a niche through fusion with an existing object – rather than through seeking to compete with the existing objects, or to engage in altruistic behaviour of a symmetric kind. There is now a whole field of evolutionary biology concerned with niche construction theory (Odling-Smee, Laland, and Feldman 2003; Laland, Odling-Smee, and Endler 2017). Remember too that the environment includes other organisms. Niche construction can involve any components of the environment. Going beyond this, organisms may use an adaptive ability (called the adaptability driver – (Bateson 2006) (2017)) to penetrate and actively change new environments.

(iv) Absorption may go a stage beyond what has been described: there may be a transfer of material from the penetrating object to the host object – for example in the way in which free bacteria became mitochondria. The best strategy for an organism seeking to cooperate with an established environment may well be to seek to merge with it – to a form of fusion with the existing object from which there is no way back.

(v) This kind of cooperative fusion-through-absorption may be possible at more than one level. In the simplest possible example, a fused object (created out of two unicellular objects) might fuse with a further unicellular object to create what we can call a higher-level object. All animals, plants and fungi consist of what are called eukaryotic cells (cells with nuclei), which evolved by fusion of ancestral bacterial in precisely this way. Clearly multi-level objects are possible. All organs in animals are multicellular objects. As a result, cooperation might happen at any one of a multitude of levels (for example there might be mid-level fusion between the components of multilevel objects). Furthermore, it is obvious that such cooperation might happen at more than one level at the same time. And it is clear that such cooperation, at more than one level at the same time, may create forms of robustness. Finally, evolutionary selection that privileges robustness might lead to extensive networks of interactions between objects.

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5. The Principle of Biological Relativity

We need theories that describe the possibility, and operation, of such cooperative fusion-through-absorption, operating at many levels. The principle of Biological Relativity, proposed by one of us (Noble 2012; Noble 2016; Noble 2017), forms the conceptual basis for such theories. The essence of the principle is that there is no necessarily privileged level of causation. Different levels of organisation have emerged during evolution and have in turn produced biochemical networks, organelles, cells, tissues, organs and the systems of whole organisms, each of which may influence the activity of other levels. The forms of causation by which they do so are different depending on the nature of the organisation that has emerged (Noble *et al.* 2019). Cells, for example, influence their molecular components (genes, lipids and proteins, etc.), by a variety of cell properties such as electrical and chemical gradients. Similarly, organs display properties that control the cells and tissues of which they are composed. Groups of organisms and whole ecosystems form types of organisation that can influence the component individuals. All levels may exhibit agency (Noble and Noble 2017), which in turn can influence the direction of evolution. It is the agency of organisms that creates the selection criteria required for group selection to work. As examples, dogs and monkeys can select against non-cooperators in their populations (Brosnan 2011; Brosnan and De Waal 2003; Essler, Marshall-Pescini, and Range 2017).

6. Diagrammatic Representation of the Principle and of the Dynamic Effect of Fusion

In this section we will represent the principle diagrammatically in Figures 1-5, including particularly the reaction to a change introduced by a symbiotic event.

Finally in this series of diagrams illustrating the main principles of biological relativity we show in Figure 5 the main levels of organisation that occur in organisms. The diagram also makes several additional points. First, the upward and downward forms of causation are represented on the left by double-headed arrows to emphasise that these act simultaneously in each integration step in simultaneous differential equation models. On the right we show that, nevertheless, the forms of causation are several and different. Second, some of the boundaries between levels have special features. This is particularly true for the topmost boundary, where causation from cultural factors is represented by the 'cloud', and the lowest boundary where there are several ways in which networks influence gene expression and gene sequences. Further details of these important differences are dealt with in Noble, Tasaki *et al.* (2019). The topmost boundary is clearly important when considering the applications of the principles of biological relativity to economics and management studies.

We now turn to the implications of these examples and ideas for economics and business. We will do this by showing how they can improve on standard concepts of economies and the firm.

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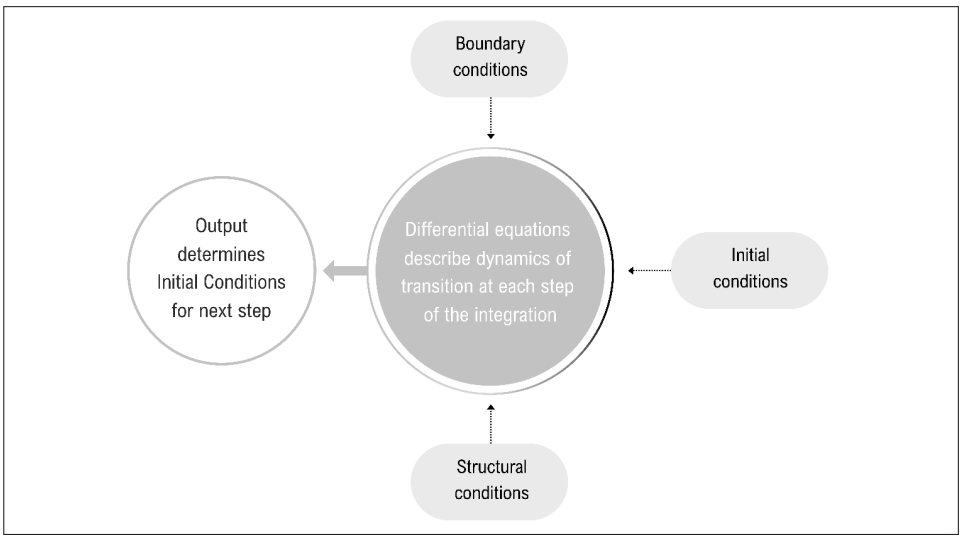

FIG. 1. Illustrating the mathematical basis of the Principle of Biological Relativity. The behaviour of the individual components of system is represented by differential equations (or their equivalent, such as difference equations) describing the dynamic behaviour of the components. At each integration step the structural, initial and boundary conditions constrain the solutions to the differential equations that follow from the initial data at that point. The output of the integration determines the initial conditions for the next integration step. Redrawn based on Noble (Noble 2012), where the Principle of Biological Relativity is explained.

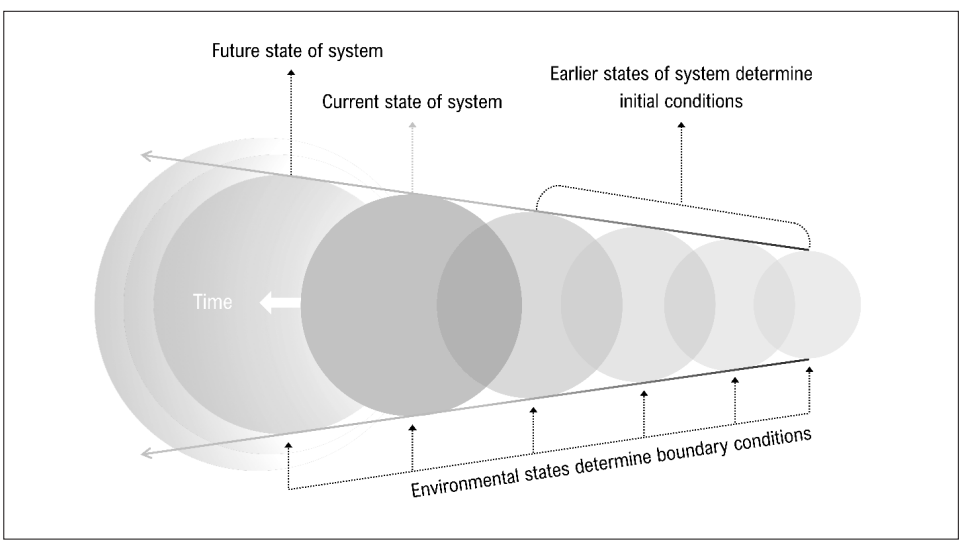

FIG. 2. Illustrating the Principle of Biological Relativity as a time series. The state of the system, such as an organism, is represented by circles at different times during the dynamic changes. Within the circles are the components of the system. External to the system, environmental influences determine the boundary conditions of the system. Previous states of the system determine the initial conditions.

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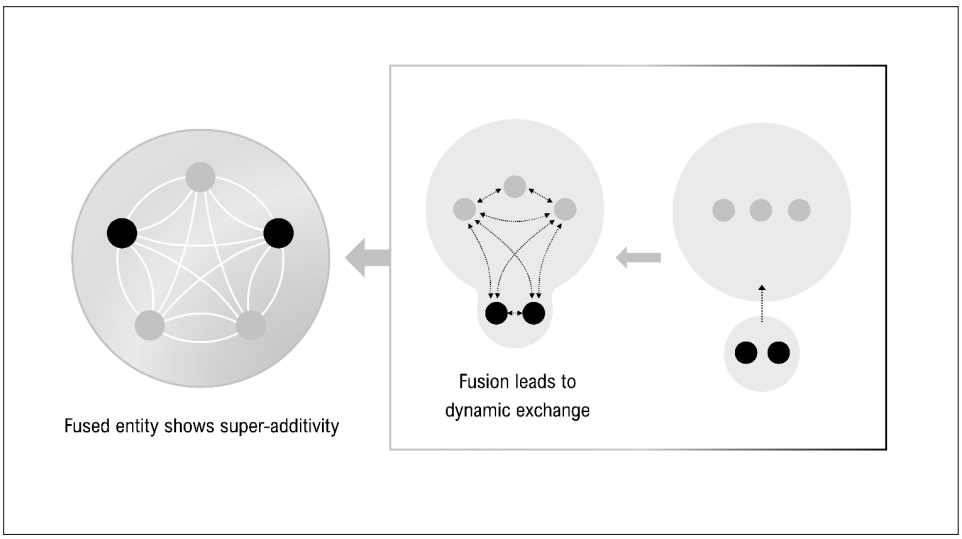

FIG. 3. This diagram represents the fusion (symbiosis or symbiogenesis) of two asymmetric organisms. Within the concepts represented by figures 1 and 2, the fusion forms a step change in initial conditions to which all parts of both organisms subsequently adjust. The dynamics of the fused entity will be different from those of the separate components, represented by super-additivity. When the two fusing organisms each possess some of the necessary but not sufficient conditions for the emergence of a higher level of organisation, it is possible that, in combination, the combined conditions may become sufficient. In such a case the higher level will emerge automatically.

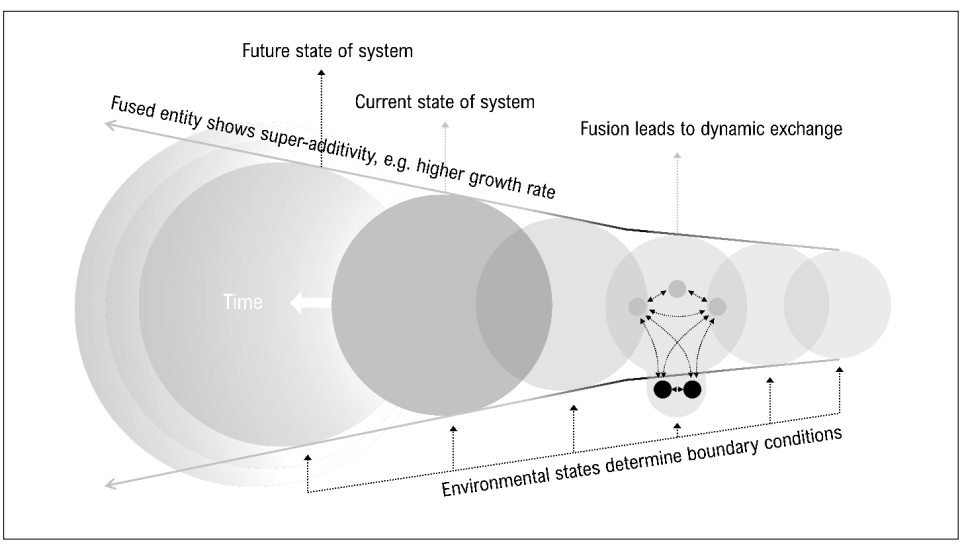

FIG. 4. As a consequence of the reaction to the step change in initial conditions, the fused system will usually show super-additivity in which the whole represents more than its parts. Possible equationsfor super-additivity are derived and discussed in Neumann Noble & Cohen, (Neumann, Noble, and Cohen 2018).

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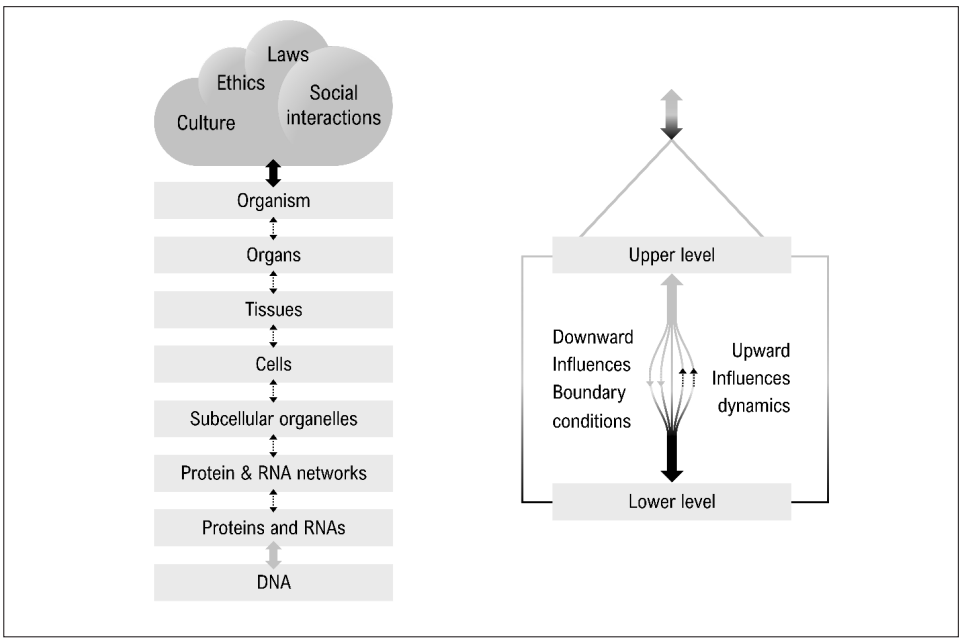

FIG. 5. Left: Representation of levels of interaction emphasising that upward and downward causation operate simultaneously and are shown as double arrows. Right: diagram showing that, within each bidirectional causal arrow, there are different forms of causation, up and down (Redrawn from Noble, Tasaki *et al.*, 2019).

7. COOPERATION IN CORPORATIONS

There are many forms that cooperation takes in economics. These include building a reputation in repeated games, the assumption of altruistic preferences, the use of team reasoning (Bacharach 1997, 1999, 2006; Sugden 1993; Sugden 2000; Sugden 2002; Sugden 2003; Sugden 2005), and Kantian optimization in which individuals do their best for a group rather than just for themselves (Roemer 2015). These suffer from fragility (in the case of repeated games, for example the infinite regress problem), the need to impose external agents (sorting mechanisms that group altruistic individuals together), multiple equilibria (in team reasoning) and the need for effective punishment strategies (both in repeated games and in Kantian optimization).

What traditional economic models do not incorporate is the greater permanence and resilience that comes from legal and institutional arrangements. In general, economics emphasizes the advantages of choice and reversibility. For example, in the context of competition in markets, contestability, by which firms can enter and exit at low cost, is supposed to promote welfare enhancing outcomes.

In contrast, institutions create arrangements that are deliberately expensive to unwind. An illustration of this is the pain and cost that the UK is currently undergoing in trying to extract itself from the European Union. The complexity of doing

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this has become progressively more evident as negotiations have progressed. The association of institutions with credible commitments has a long history. In particular it is central to Douglass North's concept of institutions (North 1993). For North, institutions are sets of rules and norms that encourage cooperation between parties that would otherwise not be observed and circumvent the strong reliance on reputation that neoclassical economics has to impose to allow individual agents to achieve similar results.

Time inconsistency provides particularly clear arguments for irreversible commitments and tying ones hands. The ability to promote cooperative behaviour by other parties today involves promising to forgo profitable opportunities tomorrow that would emerge from reneging on commitments. The profitability of many investment projects requires that the promises made by the contracting parties are actually believed and, in due course, honoured. But these promises may not be credible. We have shown that in the case of evolutionary biology new agents with higher level organisation have frequently made irreversible cooperation (Margulis 1970, 1991, 1981; Roossinck 2008). The same is true in economics and business.

None of the theories and models in economics considers the notion of the creation of new higher order entities than the individual agents. In all of the game theoretic, altruistic preference, team reasoning, Kantian optimization models, individual agents remain the decision takers. Their behaviour is influenced by this myriad of mechanisms but the notion that a 'new' agent is created is not entertained.

Why is this? The importance of the individual is sacrosanct in economics. The collective of individuals that comprise communities, societies and institutions may have different preferences from any simple aggregation of the individuals but the collective nevertheless remains the product of some aggregation of the individuals. The institution is not an ultimate decision taker. There is no mind of the collective that is distinct from those of the individuals who comprise it, irrespective of whatever collective choice rule it adopts. Humans reside at the apex and everything below is ordered in such a way as to promote their interests individually and in a variety of collective forms. By contrast, our article draws attention to the need, even in biology (see Figure 5) to recognise the causal power of social factors beyond the individual. Historically, such influences have been very important in the emergence of new social structures, as emphasised *e.g.* by Harari (2015).

There is one exception to this and even here the significance of this deviation is not widely appreciated. Corporate personhood is the notion that corporations enjoy some of the legal rights and privileges bestowed on individuals. Corporations have the right to enter into contracts with others and sue and be sued like individuals. This dates back to the Roman origins of the corporation in the *societas publicanorum* (Mayer, 2018).

While the law confers rights on corporations equivalent to those of humans, that in itself does not create an identity distinct from the individuals that comprise it. Is a corporation any more than some aggregation of the individuals? Margaret Blair points to permanent capital as a distinctive feature of the corporation that allows it to promote team production in a way in which partnerships are incapable of achieving (Blair 2003). A partnership's viability can be threatened by the decision of a

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partner to withdraw their capital. Other parties to the firm are therefore exposed to the threat of premature termination of their relations with the firm by the decision of owners to withdraw capital. That is not an option of owners in corporations with permanent capital. Decisions to invest are irreversible in a way in which in unincorporated businesses they are not.

So corporations are uniquely able to commit capital that in turn encourages others to commit to team production. They are therefore able to achieve outcomes that reversible investment forms are not. Cooperation therefore derives from the commitment of the permanent capital of corporations [48], leading to the emergence of new levels with causal power.

While the existing notion of capital permanency and team production are insightful in pointing to the distinctive feature of the corporation, they do not capture the full significance of it suggested by the analogy with fusion in biology. What is most striking about the corporation is its ability to bind its different parties – employees as well as investors – to the collective interest of the corporation as a whole. Directors have a fiduciary duty to act in a way that they believe most likely to promote the success of the company in the interests of its members as a whole. In other words, they are required to promote the development of the corporation as an entity in its own regard distinct from its individual members.

Not only do investors make commitments they cannot reverse, they contribute something that persists after they exit, namely team production, to the creation of a corporate purpose. They establish a new entity that commits the investments required to fulfil their purposes of producing «profitable solutions to the problems of people and planet» (Mayer 2018). In other words, the corporation displays features of symbiogenesis as against the symbiosis associated with partnerships and the formation of teams that are vulnerable to disintegration. They thereby provide credible commitments to the delivery of corporate purposes.

The team production capabilities of the corporation derive from fusion. The capital that investors contributed is committed in a form that creates an entity that is distinct from the component capitals that comprise it. There is a higher order level of organization than that of the individuals who contribute to it. The distinction of corporation from cooperation is clear. It is not just co-operation in the sense of joint operations; it is incorporation in the sense of inclusion in a corpus, a single body.

The insights that come from thinking of the corporation in these terms of symbiogenesis and the creation of a new entity are profound. They point towards economic progress associated with the growth of corporations as being part of a process of economic evolution in which more intricate modes of production and service delivery are created.

One of the implications of this is the role of the law in enabling companies to adopt structures that are suited to their activities. The corporate form was a legal innovation that had profound effects on human development and economic progress (Harari 2015). Viewing it as a means of commitment to alternative forms of cooperation suggests that it should embrace a variety of parties beyond just investors – employees, suppliers and communities. The law should therefore encourage the adoption of structures of engagement and participation that allow for

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similar commitments of human and social capital to those of financial capital Mayer 2013, 2018.

The analogy with symbiogenesis suggests that the new forms of organization display properties that previous ones did not and deliver outcomes that are superior to those of their predecessors. In particular, corporations are capable of delivering benefits to those they serve that allow them to compete and survive. Just as the principles of biological relativity point to the significance of higher order conditions in influencing those lower down, so firms should not be viewed as simply an engine of the investors and managers who finance and run them but as entities in their own right. The corporation imposes conditions on those who operate within it as well as being itself a manifestation of those who comprise it.

In other words, there are the very same kinds of boundary conditions (enshrined in legal documents such as contracts and constitutions) associated with corporations that biological relativity talks about as being imposed on genes by cells and organisms. And just as the natural environment imposes boundary conditions on the evolution of organisms, so too the external conditions of the market place, politics, society and regulators constrain the corporation.

How can a human construct, namely legal form, create the equivalent of biological evolution? The corporation exemplifies in a striking fashion what the relativists having been asserting in relation to biology – namely that it is not the lowest level, the gene, but the higher order conditions at the level of cells that determine biological activity. Likewise, in relation to business activity it is not the individual agents – the investors and managers – that yield the properties of the corporation but the higher order conditions that stem from its legal form.

8. Cooperation between a Corporation and its Environment

The principle of biological relativity describes the process of cooperative fusion-through-absorption that occurs in biological systems. As we have said, this principle operates in biological systems at not just one level, but at many levels. Within the economy there are a number of levels, and it appears that the processes of cooperative fusion-through-absorption can also occur at different levels.

The corporation is an institution at one level in the economic system. As we have described, a corporation as a fused object, created by the capital investments of those who invest in the firm, along with the skills – the human capital – of those employees who work within the firm. The corporation imposes conditions on those who operate within it. These are the same kinds of boundary conditions that biological relativity talks about as being imposed on genes by cells and organisms.

One level up from the individual corporation is the industry in which a corporation is located. The firms that exist within this industry – whether they be, say, the smartphone producers, or firms in the taxi industry, or corporations in the pharmaceutical industry – are constrained by the existence of other firms in the same industry. Those other firms may be competitors, but they may also be customers, or suppliers. The success, or otherwise, of each firm depends on its relations with other firms.

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The simplest versions of conventional economics sees firms as mainly being in competition with each other, each selling products to consumers. But firms can sell products to each other, and in doing so can sign long-standing contracts. These contracts act as boundary conditions, which shape the behaviour of the individual firms. Firms interact with these boundary conditions, influencing the behaviour of other firms, and the contracts that they will sign.

More than this, one firm can take over another, in a process of fusion-through-absorption. And new firms can enter a market, changing the boundary conditions faced by the already-exiting firms. In the next section of the paper we provide case studies of such entry, in the form of foreign direct investment into Korea. We will study examples of foreign entry in each of the industries mentioned above. We will show how this entry changed the conditions facing the already existing firms.

One level up from the level of particular industries is the level of the country's economy as a whole, and its legal and regulatory framework. The success of each industry, and of the firms within it, will depend not only on the relations between firms within the industry. It will also depend on the relations between firms and the regulatory agencies that influence their behaviour, and on firms' relationships with those who make the laws that determine these regulations. Such regulations also act as boundary conditions, shaping the behaviour of the individual firms and the shape of the industry in which the firms are located.

In the case studies in the next section of the paper we provide case studies of such regulatory influences. We show how regulatory processes have acted as boundary conditions where entry has taken place in the industries we study. The simplest versions of conventional economics sees regulators as being quite separate from firms, and providing boundary conditions from outside the industry, to which firms necessarily respond. Indeed, much has been written about the problem of «regulatory capture», describing how, if firms get too close to their regulators, they may subvert the intentions of regulators. But, as we will show in our examples, firms and regulators may well need to work together to create a new structure for the industry in which the foreign investor plays a role. We can view what happens as a process of fusion though absorption. The regulator ensures that the new, foreign entrant fits into the domestic industry. As this happens, symbiosis can takes place.

The modern Korean economy is a particularly good setting in which to understand this process because of the way in which Korea combines elements of western market business and economics with non-market relations based on history, bureaucracy and culture. Korea has adopted certain western business and economic practices in its economic development to create a setting in which it is highly instructive to examine how western companies seeking to enter Korea adapt to their new environment.

9. Four Business Cases of Foreign Investment in Korea: Cooperative Fusion in Action

The four case studies describe corporations 'entering' a new context – Korea. All four cases involve organizations based outside Asia. Two are entering the Korean

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market for the first time; the other two are already established there but are seeking to introduce new products.

9.1. *Cases A and B*

Organizations A and B used mobile applications («apps») to promote sharing economy activities. Both companies had grown rapidly on the back of the growing popularity of smartphones. In January 2013, Organization A chose Korea as its bridgehead into Northeast Asia. It set up a branch office in Seoul to facilitate its operations. Its app connected people seeking temporary accommodation with those that offered it. The Korean context presented two major challenges. Firstly, those providing accommodation through Organization A risked violating existing law, and secondly there was the risk of opposition from existing more traditional accommodation providers.

To address these challenges, Organization A embarked on a three-pronged strategy:

1. First, it tried actively to demonstrate to government how its innovative approach would benefit Korean society. It did this by stressing benefits for the tourism sector and for both regional and national economies. It demonstrated that by providing accommodation to overseas guests through home sharing, it would assist marginalized rural economies. The company cited evidence derived from experience in other countries of the monetary and non-monetary value to both those providing accommodation to local communities and to the wider region that benefited from the business model.
2. The company stressed to government and communities the benefit of creating additional local income that did not diminish more traditional models, and pointed out that both hosts and guests would benefit from the cultural exchange through home sharing.
3. Finally, and to demonstrate its commitment to corporate and social responsibility goals, the company worked with a Korean non-profit foundation to share its experience with young people in Korea, enabling them to develop expertise in new business systems, and create new value for the economy.

To help its accommodation providers to meet local regulations, Organization A gave practical help, by, for example, providing fire extinguishers and practical guidelines on how to meet legal requirements and to register as an accommodation business. The company held regular education events for hosts, strengthened its systems for reviewing the protection of both hosts and guests, and strictly controlled transactions between hosts and guests in the interests of guaranteeing safety.

To address the fears of traditional accommodation providers, Organization A demonstrated that its service supplemented, rather than competed with traditional markets. Its aim was to expand the industry as a whole, rather than to take market share.

To summarise, Organization A earned the trust of the authorities by showing its commitment to Korean society. It engaged with stakeholders in ways that emphasised mutual benefit. This in turn enabled it to enter the Korean market without

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any significant resistance as it added value in the ways that it had promised. Subsequently Organization A worked with the government as a key player in developing a 'policy to ease restrictions for the promotion of the sharing economy' as introduced by the government in February 2016.

Given that Korea was Organization A's bridgehead to other economies in Asia, its strategy overall positioned it for leveraging its positive approach and reputation into other markets.

In August 2013, Organization B launched a luxury car hire service with professional drivers in Seoul. Users and drivers were put in contact, and fare payments were handled through a smartphone application. Organization B immediately encountered two significant challenges. Firstly, it had begun operations without registering under the relevant Korean information and telecommunications act. This meant that the drivers were acting illegally. Secondly, it exposed itself to substantial opposition from existing providers, namely the taxi industry, which saw it as an unwelcome competitor for their market share.

Organization B did not address these issues before launching in Korea because the service was successfully operating in many other countries. Once it had correctly identified that there was a market gap in Seoul for high-end limousine services, it simply implemented a high-profile marketing and public relations campaign and began operations.

After one year, and in the absence of any countervailing arguments to those put by the taxi industry, the transport government authorities instructed the city to prosecute the CEO and the local Managing Director of Organization B for running an illegal business. They won their case and in early 2015, individual car-rental agents and drivers alike were convicted of taking part in illegal practices. The Ministry for Information and Telecommunications also brought a case against the company and in April 2015 the company ceased all services in Seoul.

Contrast this not only with Organization A, but also with the success of a similar Korean mobile messenger service, which took advantage of Organization B's difficulties to move into the car hire market, essentially offering an equivalent service, but doing so in collaboration with existing taxi businesses. This native Korean service was launched in March 2015, one month before Organization B ceased its operations. Only one year later, a survey showed 60% of all taxi passengers using the Korean app. When the relevant regulations were revised in September 2015 deregulating luxury taxi services, the Korean mobile messenger service added this segment to their existing offering. Organization B, although now legally free to reintroduce its halted service, had, inspite of a first mover advantage, forfeited its competitive edge in the market. In contrast, the mobile messenger service's strategy of collaborating with potential competitors, allowed it to develop and sustain good relations with the government, enabling it to make a much more effective market entry.

9.2. *Cases C and D*

The remaining two cases both involve non-Asian and global pharmaceutical companies both already operating in Korea.

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Since 2008, and in common with many other jurisdictions, all new drugs have been required to demonstrate both efficacy and cost-effectiveness before becoming eligible to register for National Healthcare Insurance reimbursement in Korea. Organization C wanted to launch a technologically innovative drug that targeted a specific patient group. For such a type of drug, demonstrating cost-effectiveness is challenging. Having received safety approval in 2009, Organization C started the registration process, but faced a major challenge in agreeing a price for the drug with the government. Because drug prices in Korea are used as a reference point by other governments in Asia and the Middle East when determining their own prices, agreeing a low price for Korea would have had wider financial implications. The government asked for a 52% discount on what the company proposed, much lower than the average OECD price.

Organization C respected the Korean government's position. However, it suggested maintaining its target price for the drug, while at the same time introducing a refund system. This mechanism served significantly to reduce any negative financial impact upon its global business, and at the same time, shared the risks of introducing the drug, since the government would still pay the higher up-front price and obtain a refund as and when the introduction of the drug was successful. The mechanism thus would satisfy the needs of both patients and doctors for the drug, whilst lessening the financial burden on the health insurance scheme. The company could cite similar successful practices in Europe and America.

To help achieve this solution, Organization C worked with stakeholder groups to improve the government's understanding of the underlying issue, involving experts and related associations. In particular, the Organization worked together with other global pharmaceutical companies facing similar issues. The Organization also garnered the support of patient groups and doctors, who were all eager for the release of new medicines, and the Korean National Assembly, which represented their views to government.

As a result of this widespread and co-operative interaction between various systems and stakeholder groups, active discussions ensued between leading academics, government bodies and other key stakeholder groups. These led directly to the development and introduction of a new Risk Sharing Agreement (RSA), which balanced the demands for cost control and patient access to new innovative medicines.

Organization C's drug became the first in its class to be registered under the new policy and is now being used to prolong the lives of cancer patients, for whom the other treatments have failed or are not available. It has been a major contributor to Organization C's steady sales growth in the region, and the RSA system made the launch of future drugs into the Korean market easier for the organization.

To summarise, collaboration enabled the Korean government to put in place a system to increase patient access to a high-priced cancer drug by introducing the RSA policy that permitted high-priced and targeted drugs to be accepted for registration by the Korean National Health Insurance scheme.

Organization D was similarly seeking to introduce a new drug, which had fewer side-effects and was more effective than existing treatments. The Organization

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faced two sets of challenges. Firstly, they had to gain regulatory approval for the drug. However, shortly after they applied for it there were press reports of side-effects and deaths in a neighbouring country, where the medicine had recently been launched. Secondly, after the launch, the government decided to reduce the price of the drug by over 11%.

While the permit was pending from 2001, Organization D was granted permission, on compassionate grounds, to provide an access programme to supply the medicine to Korean cancer patients for whom existing treatments had not been effective. This provided the government with Korean evidence of the safety and efficacy of the medicine resulting in approval being granted for use of the drug from 2003.

By July 2006, NGOs pointed out that the drug was more expensive in Korea than in other countries, and argued that the price should be cut by 22%. The Korean government in turn decided to re-categorize the medicine from an 'innovative new medicine' to 'general new medicine', and reduce the price by 11.3%. Organization D immediately appealed against the government's decision, initially successfully seeking an injunction suspending the decision pending the courts judgment as to whether the government's conduct was lawful. Failing to demonstrate the innovativeness of the drug, the company lost the case. Many government officials felt that Organization D would have had a greater chance of success if it had taken a more co-operative approach, worked with the government and civil society and suggested alternatives or compromises.

10. Implications of the Case Studies

In summary, we can learn from these case studies that success or failure for these non-Korean multinationals in penetrating the Korean market depended on the way in which the Korean social context was handled. The case studies show that:

(i) The location and bedding down of the non-Korean firm within Korean society – what we might call fusion-through-absorption – enables novel enterprises («new forms of life») to emerge. The resulting changes in behaviour are highly asymmetric.

(ii) Existing models of foreign direct investment provide an inadequate description of this process. They are usually static and concerned with analysing equilibria. They do not normally account for the dramatic increase in the size of objects – *e.g.* the increase in the size of the market. This is a systemic process that can only be understood dynamically in terms of the increasing benefits that the symbionts enjoy as a result of their fusion.

(iii) The best strategy for a firm seeking to penetrate an established environment may well be to seek to create a niche through fusion with an existing incumbent. Firms use an adaptive ability to penetrate existing markets, the resulting fused object then actively changes the objects which surround it, creating a new environment.

(iv) Locating an offshoot of an organisation in a new place – *i.e.* undertaking foreign direct investment – may require cooperation with other institutions in the new

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location. Our case studies provide us with examples where cooperation both with the existing incumbent and with the government – or with the industry regulator – may be necessary for absorption into a new market to be successful.

(v) Furthermore, locating an offshoot of an organisation in a new place – *i.e.* undertaking foreign direct investment – may require cooperation with the institutions in the new place at more than one level. It is self-evident that such cooperation at more than one level might create forms of robustness for such foreign direct investment. Cooperation may be required at multiple levels with no privileging of any one of them. As a result, competition in the new environment might lead to extensive networks of interactions between the new entrant and existing institutions.

11. The Biology of Business [49]

Before penetrating the foraminifera, the algae are masters of their universe; afterwards they are no longer. They become bound to the foraminifera's structure and in the process concede at least a part of their self-determination to it. Their development is no longer unitary but collaborative, the algae and foraminifera forming a combination that together has the capacity to create more than either is capable of achieving on its own.

Prior to entering Korea, a foreign company is master of its overseas universe. It defines its own destiny in relation to the Korean market. It can determine whether it will export its threat of its products, in what form and at what price. They may not be accepted or popular in the target market, they may face prohibitive trade barriers and they may violate required standards. But it is for the firm to determine what it does and how.

Once the firm enters the market it forgoes some of these rights. It concedes autonomy over the way in which it structures and conducts its business. It has to accept those of the economy and society that it is joining. If it resists and seeks to retain its rights in full, it will be rejected and repulsed, as was observed in two of the cases recorded above. Just as the algae has one form prior to entry and a collective one afterwards, so too the foreign firm transforms from an individual to a collective entity on entering the domestic market.

The insight that comes from combining two seemingly unrelated episodes at opposite ends of the evolutionary spectrum – the minute algae and foraminifera, and the massive multinational enterprise and Korean society – is that quite remarkably precisely the same processes are at work. Both involve conceding autonomy for cooperation and acceptance of rules of a game that derive from the larger structures of which the component elements have become a part.

12. The Importance of Cooperation

That the same cooperative processes are at work in the earliest and smallest elements and the latest and largest suggests that it prevails throughout at every stage in the evolutionary chain. The fact that cooperation through fusion is a critical component of the most basic biological processes, and the most sophisticated business

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and economic processes reveals that it is neither merely a human construct nor devoid of human relevance.

An understanding of biological processes has profound implications for business studies and economics. Both of these social science subjects view foreign direct investment from a competitive perspective, and one that is mechanistic. There are certain attributes that foreign firms possess, in the form of financial or material capital, human skills, cheap labour, management, intellectual property, research and development, which domestic firms lack. They therefore possess a comparative advantage over domestic firms that renders their entry profitable. They can compete successfully against their domestic rivals and gain a market share at their rivals' expense. Innate foreign superiority dominates domestic inferiority.

The management lesson to be learnt from this conventional perspective is to identify the firm's resource based capabilities, match them against the deficiencies of existing providers and the needs of the foreign market, and exploit them to best advantage, competing as aggressively as possible within the confines of local laws. It is the approach that multinational companies conventionally follow around the world.

The evidence from the four case studies presented above is that this competitive approach does not work everywhere and it might not be nearly as effective anywhere as the existing business wisdom would suggest. Adaptation and acceptance might be as important as aggression and accumulation. Awareness of this has grown in significance in the management curriculum as the variety of capitalisms has come to be increasingly appreciated. It is not therefore by any means accurate to describe the conventional competitive view as the only one. But it still retains a significant influence over economic thought.

13. Implications for Economic Theory

New tools that go beyond the kinship selection of biology or conventional repeated game models of economics are required to capture the significance of cooperation. What these models fail to reflect are the structural determinants of commitment that promote or inhibit cooperation. Not all corporations are equally suited to adapting to the new environments in which they operate. For example, those that are driven by short-term shareholder interests may find it harder to build the long-term relations that are intrinsic to cooperation. Understanding the characteristics that are conducive to the promotion and prevention of cooperation in corporations is one of the most important areas of research in management studies and one that may benefit considerably from appreciating the equivalent processes in biology.

What the case of the algae and foraminifera exemplify is that the interests of the individual organisms become bound into the collective. Their survival no longer depends on their own but on their combined preservation. They flourish and fall together as one, not separate entities. Selection is now multi-level. Were they capable of detaching themselves in the event of superior alternatives materializing then they would not be committed to a combined existence. They would be playing the economists' repeated games and vulnerable to their partner's defection.

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Recent developments in biology tell us that this is not the appropriate characterization of cooperation. It presumes a continued relevance of individual preferences that should in fact be subsumed into a collective. The ability to commit irreversibly establishes outcomes that not only dominate the reversible but also produce combined preferences that are distinct from those of the individuals. In other words, a new form of existence or life emerges from the algae and foraminifera with properties that are derivative but distinct from its constituent parts.

That is precisely how economics should characterize the corporation. It is not simply a combination of individual agents, who decide to cooperate for the reasons described earlier, stemming from repeated interaction, or altruism, or team reasoning, or Kantian optimisation. It is, instead, an organization that allows parties with different characteristics to bind themselves together in such a way as to have properties that are different from their individual ones. In other words, through irreversible commitments to the corporate whole, a new economic and social existence is established that parallels that of an emergent form of life.

Commitment occurs through the irreversible pooling of the permanent capital of the corporation, with individual contributions cemented together in a unified corporate entity that assumes a purpose of its own. Initially the enterprise is involved in a fight to achieve the critical scale required for its survival in the sea of predators that seek to curtail its life prematurely. If it succeeds, then it is sold to the next generation of owners who attempt to augment its value by combining it with other forms of capital through organic growth and acquisition. The process is therefore a dynamic one involving asymmetric agents.

As with organisms, the emergence of the corporate form reflects a combination of cooperation between autonomous agents and competition between established entities. The driver is the enhancement of corporate value. The initial decision to participate in an entrepreneurial venture is a belief that its value exceeds that of alternative options available to the initial investors.

What distinguishes this from conventional valuations is that, in assuming a life of its own, the corporation creates future options that are not available to or conceivable by its founders. In other words, the combinatorial outcomes are not computable at the outset because the future existence that the new entity creates is indeterminable in the context of other similar forms that are in the process of creation. All that each agent can do is to establish whether it will enhance its own life by committing to forgo options when entering into a new entity. In other words, its decisions are microscopic and myopic in the context of evolutionary processes that are universal and indefinite.

To address this, we create regulating entities that constrain the environment within which individual corporations operate. These are designed to provide a broader and longer context to corporate decision taking and to achieve outcomes that are collectively superior to those of individual entities. As ways of combining the activities of individual corporations, they act as unifying bodies of unified entities or corporations of corporations, with social capital, such as trust and infrastructure, binding the individual entities together.

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As in corporations, the existence of the individual component is subsumed within that of the larger entity. Each component has to find a way of cooperating in the regulating organization and contributing to the existence of the combination. That is what biological organisms do in the regulatory environment in which they operate and their survival as well as that of the universe in which they operate depends on their ability to do so. The cooperation that has been observed in foreign entrants in the Korean economy and society is therefore no different from that of the evolutionary process that occurs in all forms of life and our understanding of both is enhanced through a mutual appreciation of each other.

14. Conclusions

In this section we will summarize the parallels between co-operative behaviour in biology and its forms in economics and management, as illustrated by the case studies we have presented.

1. The process of entry into a new business environment like Korea resembles that of symbiosis or symbiogenesis in that
   (a) the interaction is asymmetric;
   (b) the subsequent process is dynamic, resulting in what we refer to as super-additivity.

   It cannot therefore be represented by models using equilibrium equations to describe interactions between entities that are essentially symmetric, apart from their selfish or co-operative choices.
2. The dynamic process can create higher levels of organisation, such as new business models involving cooperation between businesses, corporations, regulators and governments. These in turn constrain the entities forming the new process.
3. The overall result closely resembles the principle of Biological Relativity, which states that there is no privileged level of causation. The creation of higher levels of organisation and regulation constrains the components of the co-operation in a form of downward causation. As in the equivalent process in biology, the upward and downward forms of causation are not equivalent. They differ in precisely the same way. Downward causation is an organising principle arising from the ordered creation of the 'initial' and 'boundary' conditions experienced by the lower level components. But their existence is also the necessary condition for the creation of this higher-level constraint.

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